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Real-time Traffic in Cognitive IoT with Efficient Resource Allocation

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ABSTRACT

The field of communication technology have congested and unlicensed spectrum with recent research activities. It has stemmed in abandoned and unlimited interference to the low-powered wireless sensor network based Internet of Things (IoT) on the other hand, this advancement necessitated the low powered IoT to be designed with limited cost, low powered consumption and efficient spectrum utilization. The concern of the spectrum consumption is solved by Cognitive Radio (CR) network, a low-cost result to utilize the spectrum professionally. In CR network the underutilized licensed spectrum is exploited by unlicensed user opportunistically. Due to their resourceful nature, the presentation of these networks depends on the observed spectrum pattern of a main user.

Keywords: Internet of Things; Cognitive radio; Wireless sensor network.

1. Introduction

In fifth generation (5G) wireless networks and beyond, massive wireless connectivity and high-data rate are in great demand, which has attracted the attention of academics and industries in recent years. The internet of things (IoT), is an important component of the 5G and beyond, which significantly improves high-data rate multiple access for massive IoT devices [1]. In an IoT system, multiple sensor nodes connect with an access point (AP) to form a wireless sensor network (WSN), which has been widely deployed in various practical applications, i.e., external environment monitoring, event detection for emergency services, wireless surveillance for public safety, etc [2]. The sensors are typically low energy consuming devices, which suffer from energy-constrained issue that can limit their information transmission capabilities.

Traditionally, power supplies, including, batteries, are embedded in the sensors, which is periodically replaced or recharged to extend the lifetime of these sensors. This may lead to several difficulties, since the sensors are often deployed in challenging environments, infrastructures, or in human bodies. Although various research efforts have contributed to the efficient energy management policies, the lifetime of the sensors is still limited [3].

Revolution in any realm is required with the passage of time. Every field changes to go forward with better solutions dealing with the challenges of the era. Industrial Internet of Things (IoT) is revolutionizing the classical communication methodologies. With the emergence of smart devices (mobile, machines, sensors) coupled with a diverse range of applications requirements, IoT is the way forward. It is expected that 26 billion IoT devices of heterogeneous capabilities will be installed to perform functions with different Quality-of-Service (QoS) requirements by 2020 [4].

IoT gives rise to 4th industrial revolution based on Cyber- Physical Systems (CPS) with the need arising back in 2015 originated basically in Germany. Industry 4.0 defines diverse use cases ranging from inter connected digital technologies, CPS, Mobile Cloud Computing (MCC) and Internet of Things (IoT) for promoting the whole

industry in terms of efficiency, effectiveness, supporting heterogeneous data, higher production, automation, and integrating knowledge [5]. These key enabling technologies have been deployed to some extent in industrial domains such as healthcare, transportation, smart cities, micro-grids, and smart factory. This trend gives rise to intelligent, distributed and self-organizing solutions to support these application domains [6]. Deploying industry 4.0 involves three-layer implementation; physical layer, network layer, and intelligent- application layer. The physical layer comprises identification and location awareness entities i.e. actuators, sensors, and terminal devices; In the future, 5G cellular technology will support such heterogeneous networks with massive number of IoT devices. It is anticipated that future 5G networks not only provide flexibility but can optimize the usage of available resources of bandwidth, power, energy, connectivity to different applications at the same time. In the last decade, computation and processing requirements of end users have increased exponentially. It has become increasingly challenging for designers to scale the processing and data storage capabilities for users within the given device size and battery constraints.

2. Related Work

The millimeter-wave (mm Wave) frequency band has been utilized in the IEEE 802.11ad standard to achieve multi-Gbps throughput. Despite the advantages, mm Wave links are highly vulnerable to both user and environmental mobility. Since mm Wave radios use highly directional antennas, the line-of-sight (LOS) signal can be easily blocked by various obstacles, such as walls, furniture, and humans. In the complicated indoor environment, it is highly possible that the blocked mm Wave link cannot be restored no matter how the access point and the mobile user change their antenna directions. To address the problem and enable indoor mobile mm Wave networks, in this paper, we introduce the reconfigurable 60 GHz reflect-arrays to establish robust mm Wave connections for indoor networks even when the links are blocked by obstructions. First, the reconfigurable 60 GHz reflect-array is designed, implemented, and modeled. The proposed solution is validated and evaluated by both in-lab experiments and computer simulations [7].

This work focuses on the downlink of a single-cell multi-user (MU) system in which a base station (BS) equipped with M antennas communicates with K single-antenna users through a large intelligent surface (LIS) installed in the line-of- sight (LoS) of the BS. LIS is envisioned to offer unprecedented massive multiple-input multiple-output (MIMO) like gains by utilizing N passive reflecting elements that induce phase shifts on the impinging electromagnetic waves to smartly reconfigure the signal propagation environment. We study the minimum signal-to-interference- plus-noise ratio (SINR) achieved by the optimal linear precoder (OLP), that maximizes the minimum SINR subject to a given power constraint for any given LIS phase matrix, for the cases where the LoS channel matrix between the BS and the LIS is of rank-one and of full-rank. In the former scenario, the minimum SINR is bounded by a quantity that goes to zero with K. For the high-rank scenario, we develop accurate deterministic approximations for the parameters of the asymptotically OLP, which are then utilized to optimize the LIS phase matrix. Simulation results show that the LIS- assisted system can offer massive MIMO like gains with a much fewer number of active antennas, thereby significantly reducing the energy consumption at the BS [8].

This paper proposes a novel transmission policy for an intelligent reflecting surface (IRS) assisted wireless powered sensor network (WPSN). An IRS is deployed to enhance the performance of wireless energy transfer

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(WET) and wireless information transfer (WIT) by intelligently adjusting phase shifts of each reflecting elements. To achieve its self-sustainability, the IRS needs to collect energy from energy station to support its control circuit operation. Our proposed policy for the considered WPSN is called IRS assisted harvest-then-transmit time switching, which is able to schedule the transmission time slots by switching between energy collection and energy reflection modes. We study the achievable sum throughput of the proposed transmission policy and investigate a joint design of the transmission time slots, the power allocation, as well as the discrete phase shifts of the WET and WIT. This formulates the problem as a mixed-integer non- linear program, which is NP-hard and non-convex. We first relax it to one with continuous phase shifts, and then propose a two-step approach and decompose the original problem into two sub-problems. We solve the first sub-problem with respect to the phase shifts of the WIT in terms of closed-form expression. For the second sub-problem, we consider a special case without the circuit power of each sensor node, the Lagrange dual method and the KKT conditions are applied to derive the optimal closed-form transmission time slots, power allocation, and phase shift of the WET. Then we generalize the case with the circuit power of each sensor node, which can be solved via employing a semi-definite programming relaxation. The optimal discrete phase shifts can be obtained by quantizing the continuous values. Numerical results demonstrate the effectiveness of the proposed policy and validate the beneficial role of the IRS in comparison to the benchmark schemes.

The following are the major issues found from the surveys.

- ✓ Low speed of operation;
- ✓ Power consumption is high;
- ✓ Stability Factor Low;
- ✓ Discontinued operational mode.

3. Proposed System

The most attractive application of IRS is to act as a reflective relay to improve the QoS of users suffering from unfavorable propagation conditions. In this case, it resembles a full-duplex (FD) multi-antenna amplify-and-forward (AF) relay. However, the FD-AF relay needs active electronic components, such as digital-to- analog convertors (DACs), analog-to-digital converters (ADCs), power amplifiers, as well as self-interference cancellation circuits. In contrast, IRSs are meant to be realized with minimal hardware complexity and power requirements. Moreover, the received SNR through the IRS-assisted link is shown to scale quadratic ally in the number of reflecting elements [8] as opposed to the classical beam forming methods at the BS and AF relays, where the SNR scales linearly with the number of antennas. With a large number of elements, IRS can be much more advantageous than AF relays and has recently found applications in physical layer security as well as simultaneous wireless information and power transfer systems.

Routing introduced redundant fog loops for WSNs. The proposed fog loop-based scheme has two main steps. Creation of fogs using loop paths is the first step, while the second mechanism creates fog nodes in the source node areas along with many other interfering fogs within the network. This proposed scheme has helped in finding the

exact location of the source node in terms of energy efficiency and privacy. Results were compared to the efficiency offered by the Phantom Routing Scheme (PRS). The proposed scheme gives improved efficiency by 4 folds and can also improve the privacy and security up to 8 folds. Since fog computing lowers latency and offers energy saving, they are tailor-made for dealing with WSNs . Sensors in WSNs are resource-constrained; therefore energy efficiency is an important issue. It needs to be addressed for the network to increase network life-time of operation and working efficiently for a prolonged period of time. Sensors in a form of clusters collected data and send to the base station using energy-efficient routing protocols.

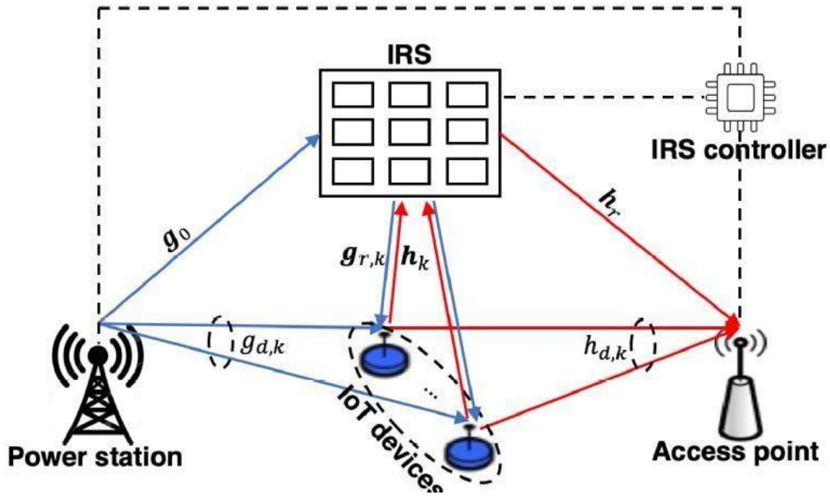

Figure 1. Architecture of the proposed system

The ZDO is responsible for defining the role of a device as either coordinator or end device, as mentioned above, but also for the discovery of new (one-hop) devices on the network and the identification of their offered services. It may then go on to establish secure links with external devices and reply to binding requests accordingly. In order for applications to communicate, their comprising devices must use a common application protocol (types of messages, formats and so on); these sets of conventions are grouped in profiles. Furthermore, binding is decided upon by matching input and output cluster identifiers, unique within the context of a given profile and associated to an incoming or outgoing data flow in a device. Binding tables contain source and destination pairs.

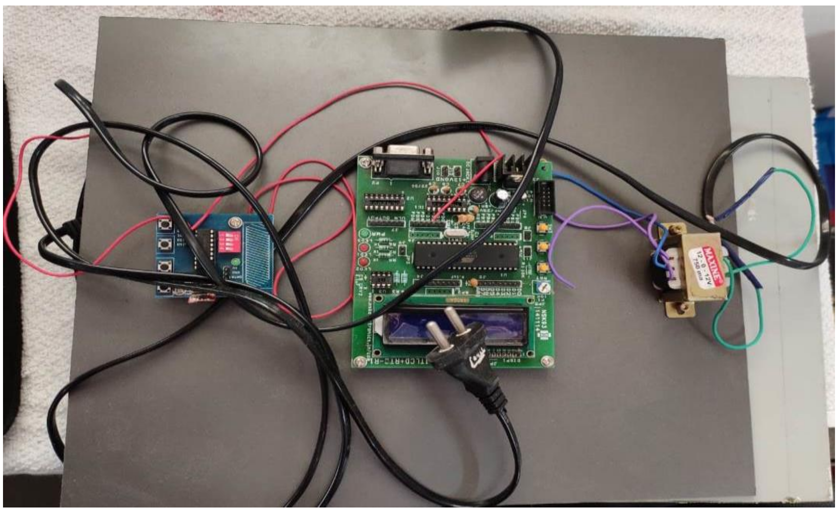

Figure 2. Proposed system

First, the IRS assisted WPSN system is investigated, where the IRS plays a helper role to improve overall throughput performance for both the downlink WET and uplink WIT by enabling energy/information reflection of the IRS during different transmission time scheduling. To evaluate the overall performance of the considered system, we maximize the sum throughput by jointly designing the phase shifts of the WET and WIT phases as well as the transmission time scheduling. Since the formulated problem is jointly non-convex with respect to these coupled variables, it cannot be solved directly. To deal with the non-convexity, we first independently derive the optimal phase shifts of the WIT phase in closed-form. Additionally, our work reveals that the IRS brings a significant WIT enhancement with an increasing number of reflecting elements. Next, we apply the application of the semi-definite programming (SDP) relaxation to jointly design the optimal phase shift of the WET phase and the transmission time scheduling, which recast the formulated problem into a convex one. Moreover, the Gaussian randomization method is used to reconstruct a suboptimal solution to circumvent the higher-rank solution found by the SDP relaxation. Although the SDP relaxed scheme can efficiently solve the formulated problem, it incurs a high computational complexity, especially for a larger number of reflecting elements. In order to deal with this issue, we propose a low complexity scheme which provides insights into the IRS deployment and allows us to derive optimal solutions to the phase shifts of the WET phase and the transmission time allocations in closed- form. To be specific, the optimal time scheduling of the WIT phase is first derived via the Lagrange dual function and Karush-Kuhn-Tucker (KKT) conditions. Next, the Majorization-Minimization (MM) algorithm is adapted to iteratively optimize the phase shifts of the WET phase. Moreover, the convergence of the proposed MM algorithm is analyzed, and the computational complexity of the proposed schemes is characterized. Then, the transmission time scheduling of the WET phase can be derived using the Lambert W function.

4. Conclusion

In this paper, we have proposed a model for improving delay and throughput in the CR-IoT for supporting critical data. We believe that CR-IoT has a better average transmission delay than conventional models for various types of traffic (critical and normal data). Simulation and mathematical analysis of CR-IoT closely match and performs better than conventional networks. In future work, we plan to extend this idea to multi hop, and multi-cluster CR based Internet of Things, where intra-cluster and inter-cluster communication will share the available licensed bands. Transmission delay and throughput for a different kind of traffic, and fairness for multi-hop communication will be studied in the near future.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this research work.

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